BNA

Daily Environment Report

DRILLING

HYDRAULIC FRACTURING

Natural gas extraction has increased dramatically in recent years with the widespread use of hydraulic fracturing to access shale gas formations. In this article, Benjamin H. Grumbles examines the facts and potential environmental impacts of fracking associated with shale gas production and concludes with some policy recommendations to protect what he calls the country's most precious liquid asset—water.

This is the first of two articles examining hydraulic fracturing. In the second article, BNA correspondents will take an in-depth look at state regulations on fracking.

Water and Fracking: Uncovering Facts and Reducing Environmental Impacts

By Benjamin H. Grumbles

A. Background

Natural gas extraction in the United States has increased dramatically. In 2010, the United States produced nearly 21.5 trillion cubic feet of natural gas,[1] the most the nation produced in over 30 years. This is due to the discovery of shale formations and a combination of technologies that allow companies to access these deposits. In fact, the most recent of these "shale plays," the Marcellus Shale, has the potential to be the second largest natural gas field in the world, containing upwards of 516 trillion cubic feet of gas. [2]

This is possible from the development of hydraulic fracturing or "fracking." This technology has existed since 1947; however, innovations combining fracking with horizontal drilling[3] opened the door for broader use in shale fields once thought to be off-limits. Broader

[1] See U.S. Energy Information Administration, http://www.eia.gov/dnav/ng/hist/n9070us2A.htm.

[2] Engelder, Terry, "Welcome to Terry Engelder's Homepage," Engelder Homepage, Pennsylvania State University. See http://www3.geosc.psu.edu/~jte2/.

DIM0137069

use has led to increased scrutiny by regulatory agencies, environmental advocacy groups, and the public.

This article examines the facts and potential impacts of fracking associated with shale gas production, including recent actions, allegations, and assessments, focusing on water.[4] Basic policy recommendations are included to improve planning, tracking, and protection of our country's most precious liquid asset.

Before a natural gas well can be fractured it must be drilled. This process has been refined since the creation of modern drilling practices in the early 20th century and involves drilling deep into the earth. While depth varies among shale plays the typical Marcellus Shale well is approximately two miles in length. In most cases, half of this distance comprises the vertical well. The vertical well is drilled using drilling muds or compressed air (air percussion drilling). Which technology is used often depends on the geology of the site. In the Marcellus Shale, operators always use compressed air when drilling through the groundwater aquifer, regardless of which drilling technique is used for the creation of the remainder of the well. In some cases, air is preferred as it requires fewer materials to be managed. It also reduces the overall water footprint of drilling operations. This process removes most of the need for water used in drilling the well, which will later require 3 million-5 million gallons during fracturing.

In either example, "closed-loop drilling systems" have the potential to reduce impacts to natural resources. A closed-loop system lessens impacts by capturing drill cuttings and other materials at the point of extraction and channeling them directly to containment systems on the well pad. The result: a significant reduction in waste and in treatment and disposal of brine gathered from drilling. For example, research in New Mexico showed potential impacts were reduced significantly as disturbance decreased by 18,000 square feet and resulted in 15,625 fewer barrels of drilling waste.[5]

During vertical drilling operators take various precautions to protect water resources. To fully isolate the wellbore, multiple steel casings are inserted and are fully cemented into the wellbore. This process is repeated until the oil and gas bearing rock is reached. The casing and cement specifications are governed by state regulations. In some jurisdictions operators are doing more than legally required. For example, in the Marcellus Shale, many are now using up to five layers of casings, often exceeding Pennsylvania legal requirements.

The New York State Department of Environmental Conservation has proposed requirements not only on the depth and number of casings required but also a stipulation that an inspector approve the casing and cement before hydraulic fracturing commences,[6] embracing the "ounce of prevention" over the "pound of cure" approach.

B. Hydraulic Fracturing and Fracking Fluid

Hydraulic fracturing includes multiple high pressure pumps, connected to the well and controlled by a command center. The pumps propel a mixture of water and sand with some chemical additives at pressures that can be as high as 15,000 pounds per square inch and flow rates that are above 100 barrels per minute in the most extreme examples.

Fluid is injected from these pumps to create or extend fractures from the well to recover the gas. The process has evolved significantly from a single stage to the current technology of multi-stage fracturing, which breaks the well into specific segments that are fractured one at a time.[7] This provides greater control while increasing production capabilities. Operators monitor the frac with tracking and seismographic imagery equipment[8] throughout the entire process.

Each well requires between 1 million and 5 million gallons of fracturing fluid for stimulation.[9] The fluid is composed mostly of water and sand that props open the fissures (99.5 percent), with the remainder being additives that reduce corrosion and other problems. Increasingly, the names and characteristics of these additives are being shared with the public. Much of this occurs through www.fracfocus.org, an industry-sponsored website developed with the Ground Water Protection Council (GWPC), where visitors can find information on a well pad basis. These constituents can also be found on state regulatory agencies' websites.

Based on current information, on average, one-third of the total water volume injected is able to be recovered[10] in the Marcellus, although percentages vary greatly depending on local conditions in the specific shale play. Shale formations are located deep underground, in some cases as deep as 9,000 feet in the Marcellus Shale. In contrast, according to the Pennsylvania State College of Agricultural Science in *A Quick Guide to Groundwater in Pennsylvania*, the deepest range for aquifers in Pennsylvania is approximately 250 feet.[11] This geological fact significantly reduces the likelihood that fracking fluids will migrate into aquifers, at least in Pennsylvania.

After initial use, fracturing fluids can be reused but may develop concentrated amounts of chemicals, natu-

---

[3] API, "Hydraulic Fracturing," API Energy, updated Aug. 15, 2011. See http://www.api.org/policy/exploration/hydraulicfracturing/.

[4] The author would like to thank John Krohn, formerly of the National Association of Clean Water Agencies and currently with FTI Consulting for his help and insights on this article.

[5] EARTHWORKS. "Closed-loop drilling systems: a cost-effective alternative to pits." Oil and Gas Accountability Project. Page 2 of 7. See http://www.emnrd.state.nm.us/ocd/documents/2007_0110OGAP.pdf.

[6] New York State Department of Environmental Conservation, *Supplemental Generic Environmental Impact Statement on The Oil, Gas and Solution Mining Regulatory Program,* Chapter 7, p. 7-42. Sept. 30, 2009. See http://www.dec.ny.gov/data/dmn/ogprdsgeisfull.pdf.

[7] Chesapeake Energy. "Hydraulic Fracturing Fact Sheet." 2011. See http://www.chk.com/Media/Educational-Library/Fact-Sheets/Corporate/Hydraulic_Fracturing_Fact_Sheet.pdf

[8] MicroSeismic, Inc. "Hydraulic Facture Monitoring & Mapping." *Hydraulic Fracture Monitoring, Mapping*. 2011. See http://www.microseismic.com/hydraulic-fracture-mapping.html.

[9] "Water Quality and the Marcellus Shale," originally aired WPSU May 27, 2010, contributors Tom Murphy co-director of the Penn State Marcellus Center for Outreach and Research and Mike Arthur, Penn State Professor of Geosciences, available at http://wpsu.org/radio/single_entry/LL-2908/stories.

[10] University of Maryland, Reconciling Shale Gas Development with Environmental Protection, Landowner Rights, and Local Community Needs, Schools of Public Policy, July, 2010.

[11] The Pennsylvania State University, *A Quick Guide to Groundwater in Pennsylvania*, 2007, available at http://pubs.cas.psu.edu/freepubs/pdfs/uh183.pdf

ISSN 1060-2976

rally occurring radionuclides, and other materials, prompting the need for proper management and disposal after the fluids can no longer be used for additional fractures.

C. Disposal of Fracking Fluids

Disposal methods are 1) injection into underground wells; 2) treatment and discharge in surface waters; and 3) use for other commercial activities. Due to a number of factors, Pennsylvania is unable to inject fluids into wells in the state. Because of this, Pennsylvania used publicly owned treatment works (POTWs) in assisting with the disposal of fracturing fluids. A select number were authorized to accept these wastes for treatment. In 2010, the state implemented special water quality standards for POTWs accepting this waste stream. As a result, POTWs treating fracturing fluids needed to ensure that their effluent meets Safe Drinking Water Act standards for total dissolved solids and a limit of 10 milligrams per liter for both barium and strontium.

POTW treatment and discharge of fracturing wastewater came under scrutiny in Pennsylvania in part due to a *New York Times* series, "Drilling Deep." The series claimed the discharges were elevating radiation levels in rivers downstream of facilities treating fracturing fluid.[12] However, testing by the State's Department of Environmental Protection (DEP) and Aqua America (the largest private water utility in the Commonwealth) refuted these accusations.[13] In April 2011, Pennsylvania discontinued this practice through a voluntary order issued by DEP. The order was issued to safeguard waters from increased levels of total dissolved solids and barium. It was possible due to industry developments that fostered water recycling rates above 90 percent.

D. Environmental Impacts to Water from Drilling and Fracking

Possible ramifications for water from shale gas production can include: increased consumption of water, increased erosion and sedimentation into waters from drill pad preparation, the potential for methane migration into private wells, and the potential for surface water contamination in the event of spills and improper disposal of produced water.

Methane migration in particular has come under greater scrutiny. This was prompted in part by scenes in the 2010 documentary *Gasland* depicting Colorado residents who could light their faucets on fire because of the presence of methane in their water, reportedly from natural gas wells. However, regulators found that in two of the three cases the culprit was naturally occurring methane.[14] In the third case, regulators found contamination was due to naturally occurring methane and *in part* to contamination from drilling, not fracturing.[15] A review of operations in Pennsylvania determined that noticeable migration can occur when drilling vertically disturbs naturally occurring methane in the subsoil, which can then migrate to water wells.[16] In Pennsylvania, regulations require drillers to notify residents within 1,000 feet of drilling activities and encourage companies to conduct pre and post testing of nearby wells.[17] If this testing does not occur, then any impacts to a water well are deemed the fault of the company. According to public records, in over 3,500 natural gas wells drilled in Pennsylvania two to three dozen water wells have been affected by methane migration.[18] It is also important to note that Pennsylvania has a long history of water well contamination from naturally occurring methane that is just now being discussed. Predrilling water testing data from one production company indicate that 25 percent of water wells surveyed in Bradford County in Pennsylvania have signs of methane before drilling occurs.

In addition, a 2009 study conducted by the Center for Rural Pennsylvania shows that a majority of private water wells throughout the state are in poor condition, with some being contaminated by arsenic or lead or both. The study also highlights that nearly half (41 percent) of the water wells tested failed to meet at least one health-based drinking water quality standard and 96 percent lacked one or more of the recommended water well construction components (including casings) that keep contaminants out of water wells. In recognition of this, the Governor's Marcellus Shale Advisory Commission recommended that the state "should enact legislation establishing construction standards for new private water wells to ensure the delivery of safe drinking water to its residents."[19]

The New York State Department of Environmental Conservation in its September 2011 *Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program* highlighted naturally occurring methane. The document stated that "the presence of naturally occurring methane in ground seeps and water wells is well documented throughout New York State."[20] The docu-

[12] Urbina, Ian, "Regulation Lax as Gas Wells' Tainted Water Hits Rivers," *New York Times*, Feb. 26, 2011.

[13] *BusinessWire*, "Aqua America CEO To PA Marcellus Shale Commission: Shale Can Be Future Economic Boom to State If Done Right Environmentally," May 20, 2011. See http://www.istockanalyst.com/business/news/5168965/aqua-america-ceo-to-pa-marcellus-shale-commission-shale-can-be-future-economic-boom-to-state-if-done-right-148-environmentally.

[14] Wisdom, Gavin, *The Durango Herald*, "Regulators Question Claims in Documentary Gasland," Jan. 20, 2011, available at http://www.durangoherald.com/article/20110121/NEWS01/701219927/Regulators-question-claims-in-documentary-%E2%80%98Gasland%E2%80%99.

[15] *Id.*

[16] Legere, Laura, "Stray Gas plagues NEPA Marcellus wells," *The Times-Tribune*, Scranton, Pa., July 10, 2011, available at http://thetimes-tribune.com/news/stray-gas-plagues-nepa-marcellus-wells-1.1173187#axzz1VPKMjBxg.

[17] Wiseman, Hannah, "Regulatory Adaptation in Fractured Appalachia, November 2010," University of Texas-School of Law, Center for Global Energy, International Arbitration and Environmental Law, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1594952.

[18] Hanger, John, "Key Gas Migration Facts Reported in July 11 Scranton Times Article," July 11, 2011. See http://johnhanger.blogspot.com/2011/07/key-gas-migration-facts-reported-in.html.

[19] Marcellus Shale Advisory Commission, *Governor's Marcellus Shale Advisory Commission Report*, p. 108, July 22, 2011. See http://teampa.com/wp-content/uploads/2011/07/MSAC_FinalReport_Web.pdf.

[20] See http://www.dec.ny.gov/energy/75370.html, specifically Chapter IV (Geology). See also Krohn, John, "SGEIS Spills the Beans on Naturally Occurring Methane in NY Water," *Energy in Depth*, Energy in Depth Northeast Marcellus Initiative, July 5, 2011, commenting on earlier version of the environmental impact statement, available at http://

ment indicates this has occurred since the 1600s and a recent sampling shows that "[t]he highest methane concentration from all samples analyzed was 22.4 mg/L from a well in Schoharie County; the average detected value was 0.79 mg/L. These groundwater results confirm that methane migration to shallow aquifers is a natural phenomenon and can be expected to occur in active and non-active natural gas drilling areas."

Overall, the Groundwater Protection Council found the potential for fracking deep shale gas wells to impact groundwater is extremely remote, as low as one in 200 million.[21]

E. Case Study on Dimock, Pa., Methane Migration

In Dimock, Pa., approximately 17 residences were potentially impacted by drilling operations. In this example, a direct linkage of contamination has yet to be proven; however, it appears that natural gas drilling may have had some impact.

In 2008, Pennsylvania DEP began to investigate reports of changes in some water wells in Dimock. Sampling began in February with some tests showing some wells jumping from 4 to 6 mg/L of methane to 35 mg/L and averaging around 25 mg/L for the next year. Since the producer had not conducted baseline water testing the company was required to take action. After negotiations, the company and DEP came to an agreement. The company would take action and provide affected families with treatment systems and a financial settlement worth twice their property values. The treatment systems utilized a methane separator with blower, storage tank with blower, ozonator, and several filters to ensure any contaminants found in the water supply would be removed. These systems made an immediate difference in the quality of water according to some residents.[22] DEP's original Consent Order also mandated the plugging of three natural gas wells that were deemed beyond repair.

After installing these treatment systems and sealing the natural gas wells, sampling results showed improvements in well water quality with some returning to naturally occurring contaminant levels. As a result, a majority of families are now able to utilize their water wells. However, some controversy remains as some residents continue to rely on imported water. Some families have been resistant to continued water sampling and are unwilling to produce samples for public disclosure. Still others are partnering with sympathetic organizations to continue to claim that the company in question has not taken steps to "fix" their water supply, a claim the company and some residents deny.

eidmarcellus.org/2011/07/05/sgeis-methane/. See also 174 DEN A-10, 9/8/11.

[21] *Modern Shale Gas Development in the United States: A Primer*, Ground Water Protection Council, et al., April 2009, available at http://www.netl.doe.gov/technologies/oil-gas/publications/EPreports/Shale_Gas_Primer_2009.pdf.

[22] Salsman, Loren. "I Know Contamination, And There's None in Dimock!" *Energy In Depth*. Energy In Depth Northeast Marcellus Initiative. Aug. 10, 2011. See http://eidmarcellus.org/2011/08/10/i-know-contamination-and-theres-none-in-dimock/.

F. Current Regulatory Structure for Hydraulic Fracturing

Regulation of hydraulic fracturing is handled primarily by states.[23] In recent years, environmental advocates have sought to require disclosure of fracturing fluid constituents and have pushed for a federal mandate. Industry initially resisted, but is now disclosing much more information through www.fracfocus.org. Halliburton was among the first to adopt this approach when it announced in November 2010 that it would publicly disclose information on its website.[24]

While the efforts to enact disclosure requirements on the federal level have not succeeded, progress has been made in the states. Wyoming was the first state to require disclosure in 2009, and Texas was the most recent when it enacted a disclosure law in June 2011.[25] Other examples can be found in Colorado and Pennsylvania. Colorado revised its regulations in 2007 and requires companies to maintain a well-by-well chemical inventory for the life of the well plus an additional five years. Pennsylvania requires material safety data sheets to be attached to every drilling plan submitted to the agency (these contain the fracturing fluid constituents), and this information is made publicly available to landowners, local governments and emergency responders. Pennsylvania also posts all additives used throughout the state on its Department of Environmental Protection website.

A comprehensive listing of state regulatory efforts can be found in *State Oil and Natural Gas Regulations Designed to Protect Water Resources*, published by GWPC. States also have outside support in drafting and strengthening their regulations through the State Review of Oil and Natural Gas Environmental Regulations (STRONGER), an entity established in 1999 to reinvigorate the state review process begun cooperatively by the Environmental Protection Agency and the Interstate Oil and Gas Compact Commission. STRONGER is a nonprofit, multi-stakeholder organization that assists states in documenting environmental regulations associated with the exploration and production of crude oil and natural gas. STONGER is funded in part by grant funding from EPA and the U.S. Department of Energy. It shares techniques and environmental strategies and identifies opportunities for state program improvement.

Federal statutes and agencies also play a role in providing oversight for certain activities associated with natural gas production from shale deposits. The Clean Water Act regulates the discharge of pollutants into waters of the U.S. and wastewater treatment plants including chemicals found in fracking fluids. It provides inspection and enforcement authority for water resource protection to a delegated state or the EPA in areas where there is no delegated entity. The Clean Water Act also provides regulatory structure mandating spill prevention control and countermeasures including management requirements associated with these activities.

[23] A good compilation of the requirements in the Marcellus can be found at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1594952##.

[24] See http://www.halliburton.com/public/projects/pubsdata/Hydraulic_Fracturing/index.html?SRC=MP.

[25] See 119 DEN A-9, 6/21/11.

   ISSN 1060-2976

G. Policy Recommendations

With the growth of shale gas drilling and fracturing, the increasing debate over potential impacts, and the continuing conflict between pro-fracking and anti-fracking positions and between federal and state roles, here are some recommended actions and policy directions. Many of these are based on the July 2011 supplemental environmental impact statement from NYDEC and the August 2011 report of the Secretary of Energy Advisory Board Subcommittee on Shale Gas Production, which was chaired by Massachusetts Institute of Technology Professor John Deutch.[26].

1. Strengthen the science

The scientific spotlight needs to shine brighter on aspects of drilling and fracturing, including the water cycle. This is a particularly useful role for federal agencies, in coordination with states, interstate compact organizations, tribes, academia, and industry.

EPA should complete its latest review and report on potential impacts to drinking water, including a defensible analysis of life cycle costs and impacts, and broaden its separate analysis of surface water impacts relevant to Clean Water Act programs and authorities. EPA's 2004 study, which found "little or no risk to ground water," was focused on coal bed methane and based on literature reviews rather than on field investigations. A thorough review, with updated information supported by case studies, would help sort facts from myths and risk-based priorities from political distractions. A scientifically credible update on risks to water will also improve the quality of debate over whether to keep statutory exemptions in place.

The Department of Energy should support continued assistance for cleaner, safer, practices. There is a need for federally supported research and technology development for safer drilling and improved environmental performance. Methane migration, and its possible association with shale gas drilling, particularly the design and construction of casings, needs continuing attention.

2. Increase disclosure and transparency

Progress needs to continue in states and industry sectors in the sharing with regulators and the public of the contents and characteristics of fracking fluids (while balancing legitimate proprietary interests), as well as the steps taken to prevent, mitigate, and respond to contamination.

Congress should revisit language in the Energy Policy Act of 2005, which arguably "clarified" but definitely exempted hydraulic fracturing from the SDWA-UIC program.[27] The effect also reduced incentives for industry to disclose contents of fracturing fluids. Congress and states should ask: Is the 2005 provision justified? Is it properly drafted? Should the "diesel fuel" recapture clause be clarified or broadened? If Congress repealed the exemption, how would EPA ensure UIC permitting program responsibilities were delegated to states and how would states administer and fund such efforts?

[26] *The SEAB Shale Gas Production Subcommittee Ninety Day Report*, August 2011, available at http://www.shalegas.energy.gov/resources/081111_90_day_report.pdf. See also 156 DEN A-1, 8/12/11.

[27] Energy Policy Act of 2005, Pub. L. No. 109-58 § 322.

The national registry for fracking fluid chemicals and additives launched in April 2011[28] is a positive step to which more time and resources should be devoted. Additional state members and supporters will build the credibility and usefulness of this tool. State legislatures should consider following the early efforts by Texas and other states in requiring or encouraging industries to participate in the registry.

3. Promote better practices and stewardship

The Deutch Commission embraces this theme, recommending the creation of an industry organization for improving practices. This model has been used before, particularly after spectacular oil spills or other environmental injuries, and the results have been mixed. The key is ensuring credibility and staying power, which requires broadening efforts of industry trade associations with outside peer review by environmental professionals and academic experts. The scope should include pre-drilling watershed planning, baseline measurement, drill pad management, waste water tracking, and closed loop systems. There is also a growing opportunity for product substitution to find environmentally benign yet effective additives. This will require time, money, and industry support to take root and grow.

4. Support improved State/interstate regulation and collaboration

Shale gas drilling and hydraulic fracturing are national issues that require specific actions and approaches tailored to local, state, and regional conditions. National environmental, legal, and industry associations should continue working on model regulatory frameworks that state, tribal, and interstate organizations can use in planning new or growing developments. Efforts by STRONGER and other organizations should be supported. It could also be useful for the Environmental Law Institute to partner with the Environmental Council of the States, the National Conference of State Legislatures, and the National Governors Association in developing a framework that builds on STRONGER.

5. Boost the 3 R's of water sustainability: reducing, reusing, and recycling water to save more and waste less

Increasingly, states and nongovernmental organizations, such as the Clean Water America Alliance, are calling for action on the complex issues embedded in the energy-water nexus. Reducing water waste and inefficiency is the first step. Water withdrawal statistics and reporting requirements to track water from beginning to end will help lighten the water footprint. More science and industry support are also needed in exploring whether waterless fracking offers additional promise.

Reusing water is critical to better stewardship. It is also an increasing requirement in state and local regulations, as industry moves closer to closed loop systems.

Recycling municipal wastewater is one of the most important environmental opportunities of our time. The WateReuse Association and other organizations should develop a research agenda and action plan to help states and localities reclaim waste water and put it to

[28] See http://www.fracfocus.org.

work in fracturing. Some communities have expressed interest in partnering with shale gas operators for this purpose. These opportunities should be maximized and utilized as much as possible. Also, industry practices like the use of reclaimed water from acid mine drainage should continue and expand. Filtering this water source and using it for fracturing operations not only removes a significant contaminant from the environment, but also lessens the industry's water footprint.

We must always keep in mind that water, after all, is our most precious liquid asset, whether it is in a stream, a treatment plant, or a fracking operation.

About the author:

Benjamin H. Grumbles is president of the Clean Water America Alliance, a national nonprofit educational organization based in Washington, D.C., committed to uniting people and policy for water sustainability (http://www.cwaa.us). He previously served as Environmental Protection Agency assistant administrator for water (2003-2008) and director of Arizona's Department of Environmental Quality (2009-2010).

The views in this article are solely those of the author and do not necessarily reflect the views or positions of his current or former employers. Nor do they reflect the views of BNA, which welcomes other points of view.